Delimitation of the Genus *Nasturtium* (Brassicaceae)

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ABSTRACT. *Nasturtium*, which is often reduced to synonymy of *Rorippa*, is recognized as a distinct genus of five species. It is more closely related to *Cardamine* than to *Rorippa*, and its distinguishing characters from these genera are given. The new combination *N. floridanum* is proposed, and a key to the species is provided.

The generic status and limits of *Nasturtium* R. Brown have been the subject of considerable controversy. In some of the recent accounts (e.g., Czerepanov, 1995; Hedge, 1968; Jonsell, 1993; Mabberley, 1997; Stuckey, 1972; Wannenmacher, 1986) the genus has been maintained, whereas in others (e.g., Al-Shehbaz, 1988; Al-Shehbaz & Rollins, 1988; Green, 1962; Jonsell, 1988; Rich, 1991; Rollins, 1993) it is reduced to synonymy of *Rorippa* Scopoli. Schulz (1936) also united the two genera, but he adopted *Nasturtium* for the combined genus, instead of the earlier-published *Rorippa*.

The basic disagreement among these treatments is whether or not the morphological differences between *Nasturtium* and *Rorippa* are sufficient to clearly distinguish the genera. There are numerous other examples of generic pairs in the Brassicaceae with similar controversial boundaries. Because of convergence in almost every conceivable character, emphasis on a small number of morphological characters can often result in artificial generic groupings within the family. The use of molecular data, along with critical evaluation of morphology, can often help resolve conflicts between competing hypotheses about the limits and relationships of genera of the Brassicaceae (Al-Shehbaz & Warwick, 1997; O'Kane & Al-Shehbaz, 1997). A case in point is the delimitation of *Nasturtium* and *Rorippa*.

Sequence comparisons of chloroplast DNA consistently support the separation of *Nasturtium* as a genus very distinct from *Rorippa*, and indicate that *Nasturtium* is most closely related to the cosmopolitan genus *Cardamine* L. This result was obtained by Les (1994), who compared sequences of the gene *rbc*L for six species in the cardaminoid group of Brassicaceae and found relatively strong support for a grouping of *N. officinale* R. Brown with *C. pensylvanica* Muhlenberg ex Willdenow, while two species of *Rorippa*, *R. sylvestris* (L.) Besser (the generic type) and *R. amphibia* (L.) Besser, formed a separate clade more closely related to lakecress (*Neobeckia aquatica* (Eaton) E. L. Greene) and horseradish (*Armoracia rusticana* P. Gaertner). Recent comparisons of the more rapidly changing chloroplast gene *ndh*F and the *trn*L-F intron and spacer regions (Price & Sweeney, in prep.) indicate that the endangered species *N. gambellii* (S. Watson) O. E. Schulz forms a well supported clade with *N. officinale* and that the genus *Nasturtium* is much more closely related to *Cardamine* than to other genera in the cardaminoid group, including *Armoracia* Gaertner et al., *Rorippa*, and *Barbarea* R. Brown.

As presently delimited, *Nasturtium* is readily distinguished from *Rorippa* by a combination of characters, including a perennial, almost always aquatic habit, hollow stems rooting at the submersed and lower nodes, pinnate emergent leaves with 1–9(–15) pairs of lateral leaflets that are never decurrent on the rachis, white flowers, curved, cylindric fruits, and reticulate seed coats, and by the absence of median nectar glands. Species of *Rorippa* are annuals or perennials of wet or mesic areas and almost always have taproots and only very rarely (e.g., *R. amphibia* and *R. fluvitalis* (E. Meyer ex Sonder) Thellung, both of which are yellow-flowered aquatics with simple leaves) root at the lowermost nodes. They have solid or rarely hollow stems, yellow or occasionally white flowers, nearly always median nectar glands, and colliculate, minutely rugose, papillose, verrucose, or reticulate seeds. The leaves of *Rorippa* range from entire to toothed, sinuate, or pinnatisect, and rarely form leafletlike lobes. When leafletlike lobes are present, they are always decurrent on the rachis, and the uppermost leaves are often simple. *Nasturtium* plants growing in water almost always produce simple leaves on submersed stems, but emergent

shoots always produce compound leaves (Michaelis, 1976; Rollins, 1978). The fruits of *Rorippa* range from globose to ovoid, oblong, clavate, or cylindric.

Cardamine is readily distinguished from *Nasturtium* by its unique fruits that dehisce explosively, by its spirally coiled valves that lack a distinct midvein, and by its flattened replum. In *Nasturtium* the fruits do not dehisce explosively, the valves have a distinct midvein and do not coil after dehiscence, and the replum is rounded.

Nasturtium as circumscribed here includes five species: *N. officinale* (the type species, which is the watercress of commerce) and *N. microphyllum* Boenninghausen ex Reichenbach (both of which are native to Eurasia and northern Africa and widely naturalized elsewhere), the Moroccan *N. africanum* Braun-Blanquet, and the North American *N. gambellii* (California, Mexico), and *N. floridanum* (Al-Shehbaz & Rollins) Al-Shehbaz & Price (Florida). A new combination for the last is herein proposed.

Nasturtium valdes-bermejoi Castroviejo, which was described from Spain (Castroviejo, 1986), appears to be a minor variant of *N. microphyllum*. It was not recognized in the revised account of the genus for *Flora Europaea* (Valentine, 1993), and its alleged differences from *N. microphyllum* clearly fall within the variation range of that species.

Further study is needed of several morphologically anomalous species that appear to fit better into *Rorippa* than into *Nasturtium*. The recently discovered New Caledonian *Rorippa neocaledonica* Jonsell (Jonsell, 1995, 1997) is an annual with decurrent leafletlike lobes, yellow flowers, and verruculose seeds, and it does not produce adventitious roots at the lower nodes. We have not seen the type or other material of the species, and we believe that the species is a good member of *Rorippa*. It appears to be related to *R. sarmentosa* (DC.) J. F. Macbride of the Pacific Islands (Jonsell, 1997; Smith, 1981; Wagner et al., 1990). Though *R. sarmentosa* has compound leaves and is sometimes perennial with adventitious roots at the lower nodes, it clearly differs from *Nasturtium* in being a mesic rather than aquatic plant, and in having solid stems, median nectaries, yellow flowers, and papillose seeds (Jonsell, 1997). The Madagascar endemic *R. laurentii* Jonsell (Jonsell, 1979) has white flowers and pinnatisect leaves, but its erect stems that do not root at the lower nodes, broadly flattened fruits, median nectar glands, and ridged seeds clearly exclude it from *Nasturtium*.

Key to the Species of *Nasturtium*

1a. Seeds biseriate in each locule, coarsely reticulate, with 25–50(–60) areolae on each side; mature fruit (1.8–)2–3 mm wide . . . . . *N. officinale*
1b. Seeds uniseriate in each locule, moderately to minutely reticulate, with more than 100 areolae on each side; mature fruit 0.8–1.2(–1.8) mm wide.
  2a. Emergent leaves not auriculate at base, 3- or very rarely 5-foliolate; seeds yellowish brown; style obsolete; plants endemic to Florida . . . . . *N. floridanum*
  2b. Emergent leaves often minutely auriculate at the petiole base, (3 or)5–15-foliolate; seeds reddish brown; style distinct; plants of other parts of the world.
    3a. Fruit abruptly ending in a style to 1 mm; leaflets entire to repand; seeds with 100–150(–175) areolae on each side . . . . . *N. microphyllum*
    3b. Fruit attenuate into a slender style 1.5–2.5 mm; leaflets often coarsely dentate, rarely subsinuate-repand; seeds with 300–450 areolae on each side.
      4a. Fruits 0.8–1(–1.5) mm wide; seeds not mucilaginous when wetted; plants of California and Mexico . . . . . *N. gambellii*
      4b. Fruits 1.5–1.8 mm wide; seeds mucilaginous when wetted; plants of Morocco . . . . . *N. africanum*

Nasturtium floridanum (Al-Shehbaz & Rollins) Al-Shehbaz & Price, comb. nov. Basionym: *Rorippa floridana* Al-Shehbaz & Rollins, J. Arnold Arbor. 69: 68. 1988. *Cardamine curvisiliqua* Shuttleworth ex Chapman, Fl. South. U.S. 605. 1887; not *Rorippa curvisiliqua* (W. J. Hooker) Bessey ex Britton, Mem. Torrey Bot. Club 5: 169. 1894; not *Nasturtium curvisiliquum* (W. J. Hooker) Nuttall ex Torrey & A. Gray, Fl. N. Amer. 1: 73. 1838. *Nasturtium stylosum* Shuttleworth ex O. E. Schulz, in Engler & Prantl, Nat. Pflanzenfam., ed. 2, 17B: 553. 1936; not *N. stylosum* (DC.) O. E. Schulz ex Cheesman, Trans. & Proc. New Zealand Inst. 43: 179. 1911; not *Rorippa stylosa* (DC.) Allan, Fl. New Zealand 1: 188. 1961; not *R. stylosa* (Persoon) Mansfield & Rothmaler, Repert. Spec. Nov. Regni Veg. 49: 276. 1940. TYPE: U.S.A. Florida: "in uliginosis subsalsis ad fluv. St. Marks, prope St. Marks, April–May 1843," *Rugel s.n.* (lectotype, designated by Al-Shehbaz & Rollins (1988); isolectotype, GH).

Rorippa floridana was proposed by Al-Shehbaz and Rollins (1988) as a new name for the Florida endemic *Cardamine curvisiliqua* Shuttleworth ex Chapman, because the transfer of the latter name to *Rorippa* would have created a later homonym of *R. curvisiliqua* (W. J. Hooker) Bessey ex Britton, a

species restricted to the western United States (Alaska south into Wyoming and Montana to California). The transfer of the epithet *curvisiliqua* Shuttleworth ex Chapman to *Nasturtium* would also create a later homonym of *N. curvisiliqua* (W. J. Hooker) Nuttall ex Torrey & A. Gray. This species was also known as *N. stylosum* Shuttleworth ex O. E. Schulz, but this name is also a later homonym of the New Zealand endemic *N. stylosum* (DC.) O. E. Schulz ex Cheesman.

Literature Cited

Al-Shehbaz, I. A. 1988. The genera of Arabideae (Cruciferae; Brassicaceae) in the southeastern United States. J. Arnold Arbor. 69: 85–166.

——— & R. C. Rollins. 1988. A reconsideration of *Cardamine curvisiliqua* and *C. gambellii* as species of *Rorippa* (Cruciferae). J. Arnold Arbor. 69: 65–71.

——— & S. I. Warwick. 1997. The generic disposition of *Quidproquo confusum* and *Sinapis aucheri* (Brassicaceae). Novon 7: 219–220.

Castroviejo, S. 1986. *Nasturtium valdes-bermejoi*, sp. nov., de la Provincia de Huelva. Anales Jard. Bot. Madrid 43: 15–19.

Czerepanov, S. K. 1995. Vascular Plants of Russia and Adjacent States (the Former USSR). Cambridge Univ. Press, Cambridge.

Green, P. S. 1962. Watercress in the New World. Rhodora 64: 32–43.

Hedge, I. 1968. Arabideae. *In:* K. H. Rechinger (editor), Fl. Iranica 57: 193–218. Akademische Druck-u. Verlagsanstalt, Graz.

Jonsell, B. 1979. New taxa of Cruciferae from East Tropical Africa and Madagascar. Bot. Not. 132: 521–535.

———. 1988. Cruciferae. *In:* C. G. G. J. van Steenis (editor), Fl. Malesiana, ser. 1, 10: 541–560. Kluwer Academic Publishers, Dordrecht.

———. 1993. *Rorippa*. *In:* T. G. Tutin et al. (editors), Flora Europaea, ed. 2, 1: 344–345. Cambridge Univ. Press, Cambridge.

———. 1995. Une espèce nouvelle de *Rorippa* (Cruciferae) de Nouvelle-Calédonie. Bull. Mus. Natl. Hist. Nat., Paris, ser. 4, 17: 175–177.

———. 1997. Cruciferae (Brassicaceae). *In:* P. Morat (editor), Fl. Nouvelle-Calédonie 21: 81–117. Muséum national d'Histoire Naturelle, Paris.

Les, D. H. 1994. Molecular systematics and taxonomy of lake cress (*Neobeckia aquatica;* Brassicaceae), an imperiled aquatic mustard. Aquatic Bot. 49: 149–165.

Mabberley, D. J. 1997. The Plant-book, ed. 2. Cambridge Univ. Press, Cambridge.

Michaelis, F. B. 1976. Watercress (*Nasturtium microphyllum* (Boenn.) Rchb. and *N. officinale*) in New Zealand. Aquatic Bot. 2: 317–325.

O'Kane, S. L., Jr. & I. A. Al-Shehbaz. 1997. A synopsis of *Arabidopsis* (Brassicaceae). Novon 7: 323–327.

Rich, T. C. G. 1991. Crucifers of Great Britain and Ireland. Bot. Soc. British Isles Handbook 6: 1–336.

Rollins, R. C. 1978. Watercress in Florida. Rhodora 80: 147–153.

———. 1993. The Cruciferae of Continental North America. Stanford Univ. Press, Stanford.

Schulz, O. E. 1936. Cruciferae. *In:* A. Engler & K. Prantl (editors), Nat. Pflanzenfam., ed. 2, 17B: 227–658. Verlag von Wilhelm Engelmann, Leipzig.

Smith, A. C. 1981. Brassicaceae. Flora Vitiensis Nova 2: 703–711. Lawai, Hawaii.

Stuckey, R. L. 1972. Taxonomy and distribution of the genus *Rorippa* (Cruciferae) in North America. Sida 4: 279–430.

Valentine, D. H. 1993. *Nasturtium*. Pp. 345–346 *in* T. G. Tutin et al. (editors), Flora Europaea, ed. 2. Cambridge Univ. Press, Cambridge.

Wagner, W. L., D. R. Herbst & S. H. Sohmer. 1990. Brassicaceae. Pp. 398–414 *in* Manual of the Flowering Plants of Hawai'i, vol. 1. Univ. Hawaii Press & Bishop Museum Press, Honolulu.

Wannenmacher, R. 1986. Cruciferae. *In:* G. Hegi (editor), Illustrierte Fl. Mittel-europa 4(1): 73–514. Verlag Paul Parey, Berlin.